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Environment, Safety, and Health

## Volume I

## Part 4: Feedback and Improvement

# 4.6
# Incident Analysis Manual

**(Formerly H&SM S4.08**

**Recommended for approval by the ES&H Working Group**

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**New document or new requirements**

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**4.6**

**Incident Analysis Manual***

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**Incident Analysis Manual**

# 1.0 Introduction

## 1.1 Purpose and Scope

All operations at LLNL must be planned, and the hazards associated with each operation must be identified and assigned effective controls and barriers so that work activities can be conducted safely and with minimum impact on the environment. An important aspect of feedback and improving operations is the analysis of any accident or incident that may occur.

An "incident" is a sequence of events or conditions that could result in an accident, injury, illness, and/or a reportable occurrence. The term "incident" is used to broadly encompass many types of events because numerous environment, safety, and health (ES&H) requirements for incident notification, analysis, and reporting do not allow for simple categorization or development of procedures for each type of incident. The Department of Energy (DOE) uses the word "occurrence" instead of "incident."

Contract 48 prescribes the requirements for conducting investigations to prevent recurrence, and to contribute to improved environmental protection and safety and health of DOE employees, contractors, and the public.

These requirements include categorization of occurrences related to safety, security, environment, health, or operations ("Reportable Occurrences"); DOE notification of these occurrences, and the development and submission of documented follow-up reports. These occurrence reporting directives further require that the notifications be timely in accordance with the significance of the occurrence, and that the written reports contain appropriate information describing the occurrence, significance, casual factors, and corrective actions. (Reference: Document 4.3, "LLNL Implementing Procedures for DOE Order 232.1, Occurrence Reporting and Processing of Operations Information," in the *Environmental, Safety, and Health (ES&H) Manual*.

This supplement provides requirements and guidance for managers, committee members, and other individuals responsible for appointing or serving on an incident analysis committee. Appendix A contains terms and definitions used in this supplement. The other appendices provide recommended guidance.

## 1.2 Requirements for Investigating an Incident

DOE is required to investigate certain accidents or incidents by way of the following boards:

- **Type A—**An investigation conducted for the more serious accidents and is appointed and managed by the office of the Assistant Secretary for Environment, Safety, and Health.
- **Type B—**An investigation conducted and managed at the field level. However, the elements of the investigation and the report format are the same.

LLNL is required to assist in these investigations, as necessary. Document 4.5, "Incidents-Notification, Analysis, and Reporting," in the *ES&H Manual* provides details on how LLNL supports the DOE Board process. LLNL uses less formal boards (e.g., Supervisor's Accident Analysis Reports, Incident Analysis Committees) for analyzing accidents or incidents unless the DOE/Oakland (OAK) Operations Office manager appoints a Type A or Type B board. If a Type A or Type B board is appointed, Laboratory management may accept the analysis of the DOE appointed board or appoint an LLNL committee to conduct a separate incident analysis.

## 1.3 Notification of an Incident

All onsite and offsite incidents involving a Laboratory employee on a work-related assignment must be immediately reported to the responsible work supervisor. Upon learning of the incident, the supervisor shall:

- Gather preliminary information;
- Preserve the incident scene where appropriate (see Section 1.4);
- Notify the environmental, safety, and health (ES&H) team and higher-level management of the incident in accordance with the guidelines for his/her directorate.

The associate director (or his/her designee) shall notify the Laboratory Emergency Duty Officer (LEDO) of the incident. DOE may also require notification. For more details on incident notification, see Document 4.5.

## 1.4 Immediate Corrective Action and Preserving the Incident Scene

Following an incident, as available, the work supervisor, lead experimenter, Facility Point-of-Contact, senior person present, and emergency response group commander shall do the following:

- Take appropriate action to make the area safe.
- Preserve the incident scene in a manner consistent with their responsibility for emergency control operations to retain valuable information for the incident analysis. On the other hand, some immediate corrective actions may be necessary to prevent other incidents from occurring. Individuals responsible for securing the incident scene should balance these two activities carefully.
- Photograph the scene before too many changes are made (see Document 4.5).

## 1.5 Incident Analysis Responsibilities

### 1.5.1 Management of Authorizing Organization

Following an incident, management of the authorizing organization (department head, division leader, or other person having a similar program position) shall ensure that

- Immediate corrective action is taken and that the incident scene is preserved (see Section 1.4 link).
- Appointment of an incident analysis committee is considered in any of the following situations:
  - — If the consequences of the incident are serious (see Appendix A for definitions of a recordable injury/illness).
  - — If, in management's view, the incident could have been serious.
  - — If the Supervisor's Accident Analysis Report does not adequately address the objectives of an incident analysis. An analysis completed by the incident analysis committee is generally more independent, detailed, and complete than one done by the supervisor responsible for the activity. Management should consult with the ES&H Team leader regarding this matter.
  - — If the incident was reported to DOE as an emergency occurrence (see Document 4.5).
- Reasonable and appropriate corrections recommended in the incident analysis report are implemented in the manner described in Section 7.1.

### 1.5.2 Work Supervisors

Work supervisors of employees who are injured or become ill from an occupational accident shall conduct the preliminary analysis to obtain information required for the Supervisor's Accident Analysis Report (see Document 4.5).

### 1.5.3 ES&H Team

The ES&H Team shall

- Consult with management about the advisability of appointing an incident analysis committee;
- Provide the appointing manager with the incident analysis report number obtained from the Incident Analysis Report Archive coordinator;
- Inform management of any circumstance that could interfere with preparing a complete and factual incident analysis report;
- Provide consultation to the incident analysis committee upon request.

# 2.0 Forming an Incident Analysis Committee

## 2.1 General

Management of the authorizing organization (department head, division leader, a person having a similar program position, shall appoint an incident analysis committee. Where more than one organization is involved in the incident, the management of both organizations shall appoint a joint committee.

The appointing manager shall confirm all appointments with the managers of committee members before preparing the appointment memo (see Appendix B). This memo shall include the names of the appointees; the scope of the analysis; the incident analysis report number, which can be obtained from the ES&H Team; the account number to which committee members can charge their time, including the budget available within that account; and the date the committee should complete its report. Approximately one month should be allowed for a thorough analysis.

## 2.2 Committee Members

The appointing manager selects the committee members and designates the chairperson after consulting with the ES&H Team leader. All members must be willing to devote the time necessary to the assignment and have a security clearance appropriate for the

location of the incident, and for the issues involved. At least one member should have had training in incident analysis; other members should have experience in the subject matter or in incident analysis methods. Consideration should be given to selecting at least one member from an organization that is not involved in the incident. Employees of the Hazards Control Department may *not* be appointed as chairpersons of an incident analysis committee. NOTE: Committee members shall not have supervisory control over each other or of the work activity, nor should they have a vested interest in the incident or in the outcome of the incident analysis.

### 2.3 Consultants and Specialists

Consultants and specialists have detailed and specialized knowledge or skills that may be useful during an incident analysis. Consultants are appointed to the committee but need only attend meetings when appropriate. Specialists are designated by the committee and shall confer with the committee only when requested.

### 2.4 Committee Support Services

The organization appointing the incident analysis committee is responsible for the cost of the analysis and for providing any support services required. The chairperson should discuss major committee needs with the appointing manager or the ES&H Team leader.

## 3.0 Committee Operation

### 3.1 General

An incident analysis committee operates under the general guidance of the committee chairperson. Other members are assigned tasks as the committee deems necessary, but major decisions affecting committee operation shall be agreed upon by a majority before execution.

If it becomes apparent during an analysis that there is no ES&H incident, the chairperson should immediately notify the appointing manager so that he/she can disband the committee.

### 3.2 Taking Control of the Incident Scene

Unless otherwise designated by the appointing manager, the committee chairperson should take control of the incident scene from the work supervisor and obtain any physical items that may have been removed. If the incident involved an emergency, the

committee shall assume control as soon as the emergency response group completes its activities. Before any clean-up efforts are attempted, committee members shall remind others involved with the incident to secure the scene and any significant physical items such as videotapes and computer data.

### 3.3 The Committee's First Meeting

After taking the necessary steps to ensure that the incident scene has been preserved, the chairperson shall schedule a meeting and arrange for a person knowledgeable about the incident to give a short briefing to the committee. The committee shall do the following at this meeting:

- Select a meeting room to conduct business (e.g., interviews).
- Decide when to visit the incident scene, and determine if additional photographs are required.
- Obtain written statements that may have been requested of individuals at the incident scene. These statements should be reviewed before conducting interviews.
- Arrange to interview participants, bystanders, management staff, support staff, or anyone who may have useful information. Allow approximately one hour for each interview.
- Obtain maps, diagrams, and photographs that may be helpful in the analysis.
- Select a date to start preparing the incident analysis report.
- Set the date, time, and place for the next meeting; exchange names, mail codes, and phone numbers.

### 3.4 The Committee Meeting Room

Committee members should select a large, comfortable, and quiet meeting room that would enable them to perform their tasks without interference. The room should have a lock, good lighting, chalkboards, wall space for posting charts and other items, and a telephone.

### 3.5 Committee Safety

The committee chairperson is responsible for the safety of all committee members. He/she may request guidance from the ES&H Team when necessary. Committee members must exercise care when conducting the analysis and follow all established

procedures and warning signs designed to protect the health and safety of personnel. *Enthusiasm for the task at hand should not overcome good sense.*

**CAUTION**

If it is necessary to reconstruct the incident, be sure that no one recreates an injury or illness at the same time. Do not allow anyone to operate valves, switches, or control buttons unless it is necessary and one is sure that this action will not cause another incident.

### 3.6 Committee Authority

The incident analysis committee is authorized to obtain information or review any document, report, or other record that will help during the analysis to produce a factual report. To meet this objective, the committee must have the full cooperation of all Laboratory employees. The committee chairperson shall discuss any situation that prevents the committee from doing its work with the appointing manager, the head of the Hazards Control Department, or the Laboratory Site Manager.

### 3.7 Releasing Information During the Analysis

The incident analysis committee may provide information about an incident to the appointing manager, supervisor, Hazards Control Department, and Laboratory Public Affairs Office, as appropriate. Contact with the public or news media, however, should be made through the Laboratory Public Affairs Office. Although it is necessary to communicate information known about an incident in a timely manner (especially if the analysis will take more than a few days), the committee must be cautious about the information it releases until the incident report has been signed and submitted to the appointing manager.

The medical condition of injured workers may be released *only* on a need-to-know basis. If necessary, contact the Health Services Department.

### 3.8 Finding Evidence of Criminal Activity

If criminal activity (e.g., sabotage or other malicious act) is uncovered during an incident analysis, the committee chairperson should discuss the matter with representatives of the Hazards Control Department and the Safeguards and Security Department. A concurrent investigation by the Safeguards and Security Department may be necessary to establish the validity of any suspicion and to identify the persons involved.

# 4.0 Gathering Information

## 4.1 Introduction

The gathering of accurate and complete information is necessary if an incident analysis is to be a useful tool for managers. Therefore, committee members should analyze the incident in a timely manner so that the recollection of people and the condition of the physical items involved do not degrade before concluding the incident analysis. To ensure completeness, the analysis must not only explain *what* happened during the incident but more importantly *why* it happened.

## 4.2 Information Recording

Each committee member starts collecting information about the incident from the time the committee is appointed. Notes can be handwritten or typed, or a tape recorder may be used. In all cases, the information must be properly identified, specifying the source, date, time, and place; who took the information; and whether the information is based on facts or speculation or was staged. Committee members should compare notes frequently to ensure accuracy.

**Note:** Some analysts record their findings in a bound notebook; others use loose leaf and a three-ring binder so they can add pertinent documents collected during the analysis. The Incident Analysis Interview Record may be used to take notes during interviews.

## 4.3 Gathering Information from the Incident Scene

The committee shall do the following:

- Inspect the incident scene and other locations as necessary, supervise the taking of additional photographs, if required, and collect other information of significance to the incident soon after the first meeting. Upon obtaining the information needed from the incident scene, the committee should release the area to the responsible person unless another group is conducting a concurrent analysis. The committee chairperson should inform the appropriate area supervisor and the ES&H Team leader of this action and about any hazardous condition that may be present in the area.
- Contact the Technical Information Department (TID) to obtain a professional photographer, if additional photographs are necessary. If this is not possible, have someone else take the photographs using an LLNL camera. Take as many photographs as necessary, including close-up photographs of

significant details (e.g., scratches, gouges, smears, fractures, relative positions of items). At least one member of the committee should accompany the photographer to direct his/her efforts and to record information about each photograph. Do not hesitate to tell the photographer the angles the photographs should be taken and whether reference items (e.g., rulers and coins) are required to give the picture size-perspective. NOTE: The TID request should indicate whether any photograph contains sensitive or classified information.

- Record information about the scene such as unusual debris, tire marks, scratches, unknown fluids, switch positions, knob and dial settings, other recognized anomalies, the casual remarks of bystanders, or anything else that seems useful.
- Not operate valves, push buttons, and switches unless the consequences of such actions are known. Any changes the committee makes at the incident scene should be recorded.

The following may also be useful to the incident analysis:

- **Preincident photographs—**If available, these photographs may be compared with post-incident photographs to help explain the incident. Staged photographs of the incident may be taken at a later time if they will help clarify the final report.
- **Diagrams and sketches**—These may be used as substitutes for photographs. Diagrams and sketches can be especially useful when classified information is involved (e.g., the classified information may be deleted) or when it is necessary to illustrate movement (e.g., missile location after an explosion, vehicle movements before and during an incident). Record directions, distances, and other relevant factors.
- **Maps**—These show the relative locations of buildings and events. Maps should be used to plot the location of personnel who are injured or have become ill as a result of a hazardous material release. This empirical "time and place" information is not easily obtained by ordinary means and therefore should be recorded for inclusion in the incident analysis report. The information is also useful for planning adequate evacuation distances in future emergencies.

### 4.4 Expert Examination of Physical Items and Materials

In situations where it is difficult to determine the role (the presence, absence, or failure) a particular item played in an incident, a consultant (or specialist) may be required to make a proper determination. This person may examine the physical items at the

incident scene or at another location. Items removed and their original location must be recorded, labeled, and preserved from disintegration or change.

### 4.5 Conduct of Operations and LLNL's Integrated Safety Management (ISM) Work Cycle

During interviews, it is essential for the committee to gather information about the incident and evaluate the steps taken by the authorizing organization to plan, operate, and assess the activity involved. This information should then be compared with the ISM work cycle, described in Document 2.2, "Managing ES&H for LLNL Work," in the *ES&H Manual*. Differences between how the activity was conducted at the time of the incident and the planned operation should be evaluated carefully to determine if such differences may have been a cause of the incident. Documented conduct of operations in facilities also should be examined. (Reference: Document 3.5, "Conduct of Operations for LLNL Facilities," in the *ES&H Manual*.

### 4.6 General Guidelines for Interviewing

The committee shall do the following:

- Begin its interviews soon after an incident to obtain information about the immediate events associated with the incident, including how the activity that caused the incident was planned and conducted.
- Interview individuals in the following order:
  - — Supervisory personnel
  - — Personnel at the scene
  - — Upper management
  - — Health Services personnel (if any illness or injury is involved)
  - — Safety personnel
  - — Middle management

  In each group, interview bystanders before participants and friendly interviewees before hostile ones. Interviewees shall not be denied the right to have an adviser present if they so desire.
- Interview only one person at a time. This prevents interviewees from modifying or supplementing their memories based on what others may have said. A tape recorder may be used to record the interview if the interviewee does not object. Note, however, that such a device may influence the interviewee's response(s).

- Keep the interview short, informal, and simple; use language the interviewee understands. Opinions are acceptable provided they are recognized as such.
- Set a positive tone during the interview. Put the interviewee at ease by conducting a friendly interview, not an interrogation. Do not irritate or argue with an interviewee. On the other hand, control the interview—do not allow the interviewee to take charge. If the information exchange becomes too bogged down, an occasional lead-on sentence may be, "Can you tell me anything more"? Do not rush the interview, and do not be afraid of silence.
- Examine in detail pertinent facts uncovered from the interview to determine if they make sense, to corroborate prior information, and to evaluate the interviewee's credibility. Where there is a discrepancy between statements, find a logical explanation if possible. If the interviewee made an error in judgment, conduct the interview in a way that will get to the "original logic" that led to the error. This is not always easy because the interviewee may have forgotten the original logic or may not want to admit to the error in judgment. But it is important to understand the original logic (not to be confused with post-incident alibis and rationalizations) to eliminate similar errors in the future. *Remember, the committee's objective is not to fix blame but to reduce risk.*

If possible, area management should keep interviewees busy with normal work activities until it is their turn to be interviewed.

### 4.7 Conducting the Interview

The committee may use the guidelines in Appendix C during interviews.

### 4.8 Gathering Information from Other Sources

Some of the information the committee needs for its investigation may already exist. These include descriptions of facilities, budgets, schedules, safety procedures, equipment records, design drawings, monitoring systems and records, training records, inspection and maintenance records, and personnel records. The committee should request this information early in the analysis phase for evaluation. Be judicious about the information requested because too much paper can be a burden. Documents obtained should be organized in a manner so that they can be easily found, and each committee member should have a copy for the investigation.

Medical examinations of the injured and analyses of body fluids or other tests may be helpful in determining why an incident occurred. If necessary, contact the Health Services Department.

### 4.9 Safety Deficiencies Not Related to the Incident Under Analysis

All errors, omissions, or safety deficiencies relevant to the incident must be included in the incident analysis report. Those that are not relevant should be documented in a memo and sent to the appropriate manager.

# 5.0 Evaluating and Organizing Information

### 5.1 Introduction

The incident analysis committee must evaluate and organize the information obtained and compare it with existing data to determine if there are any inconsistencies. Various methods are commonly used to organize events associated with an incident. They include single-line and multi-level time-ordered events (TOE) charts, word processors, or index cards on which the information is placed chronologically. New information obtained is inserted into the existing "stack" of cards in chronological order.

### 5.2 Organizing the Information Using Causal Events Charting

Time-ordered event (TOE) charts are valuable aids to analyses because of their ability to organize complex information, guide the analysis, validate and confirm the true sequence of events, simplify the organization of the final report, and depict in time-ordered sequence the events and conditions associated with a particular incident. An event is defined as one operator (animate or inanimate) performing one action. Complex events are divided into subevents that show the actions of each operator involved.

The committee should continue to gather information until all gaps on the chart are filled and significant inconsistencies identified in this process are resolved.

#### 5.2.1 Single-Line TOE Charting

The single-line TOE chart is the easier of the two charting methods. It requires that all significant events be placed in chronological order on index cards, pre-gummed sheets, or on a computer. Associated conditions are also entered on cards and then placed on the chart above or below the event to which they pertain. If a computer is used, the events should be placed in the left column with associated conditions in the right column at the same level. Although this method can easily detect gaps in the information obtained, it does not easily recognize inconsistencies and upstream (precursor) processes. For a more complete description of a single-line TOE chart, see the DOE booklet *Events and Causal Factors*.[1]

### 5.2.2 Multi-Level TOE Chart

The multi-level TOE chart assigns a single event line to each operator and allows each operator's actions to be traced step by step and from place to place—from the time the event began through the emergency response. Although this method is more complicated than the previous one, it can be more effective in determining the upstream processes that caused the incident. For a complete description of this method, see Appendix D, "Time-Ordered Events Charting."

This TOE charting method is based on the multilinear events sequence. It charts principles developed by Ludwig Benner, Jr.,[2] using the basic principle that everyone and everything always have to be someplace doing something (Benner's Law).

## 5.3 Evaluation of Barriers and Administrative Controls

Almost every incident can be viewed as a case where unwanted energy transfers to a target because of inadequate controls. Controls include physical barriers and behavioral controls.

To trace the energy flow, the committee shall

- Start with the incident and trace the energy flow back to its source. Be careful to observe the laws and principles of nature. If more than one type of energy is involved, each should be traced separately.
- Evaluate existing barriers and controls to determine why they did not prevent the unwanted energy transfer.
- Determine why a required control was missing or not used.

## 5.4 Evaluation of Hardware Performance

Environmental factors and the quantity and quality of energy delivered to the hardware can affect the performance of hardware. Examples include

- Rusting, "gumming-up," overheating, and freezing of equipment;
- Breakage of metals and plastic parts due to repeated stress;
- Deterioration of moving parts;
- Damage to equipment because of overloading. This can cause failure at a later time;
- Overcrowding of facilities, thereby making them inadequate for the work required.

The committee must determine if the design, inspection, testing, maintenance, or funding programs were less than adequately planned or operated thereby causing the incident.

### 5.5 Evaluation of Human Performance

Performance errors must always be considered when analyzing an incident. Several years ago, Rigby[3] described performance error as follows:

Both people and what they do are very complex. In treating complexity, it has become customary to presume that performance will vary but that variability is not important as long as it is within certain limits. Deficiencies such as defects, failures, occurrences, and errors occur when those limits are exceeded. Thus, in the most general and practical sense, a human error is any member of a set of human actions that exceeds (fails to meets) some limit of acceptability. An error is only an out-of-tolerance action, and the most important ingredients in any discussion of error are definitions for both the set of actions and the tolerance limits that define the errors for those actions.

Every human action is an opportunity for error. An action may be a visible act, such as a control movement; an internal process, such as reading; or even a lack of activity, such as waiting or omitting a procedural step.

The primary focus in many incident analyses is on errors in the tasks workers perform. Errors and omissions by management are probably the most important factors in every incident, yet they are seldom considered during an incident analysis. The committee must identify both management's and workers' errors and omissions and determine the changes necessary to improve the organizational system and to reduce the chances of a recurrence.

### 5.6 Evaluation of Use of Accepted Practices During Conduct of Operations

Practices accepted for the conduct of operations are based on information from codes, standards, and regulations; commonly used scientific, engineering, and management principles consistent with the operation of a safe work activity; and actions and conditions that are a fairly uniform part of our culture (e.g., red signifies danger or stop, valves are turned off in a clockwise manner, electric switches are turned off by pushing the lever down). Accepted practices should always be given consideration. Disregard for such practices without good reason usually reflects a management system that is not in control of its operation and a system that can cause a higher-than-normal accident rate.

The committee must determine why applicable accepted practices were not used or, if used, why they did not prevent the incident.

### 5.7 Evaluation of Change and Its Effects

A change in an activity, especially a research activity, is an important factor that can contribute to an incident. Change can be viewed as a perturbation in an activity that is in a state of stress equilibrium (homeostasis). When this perturbation is too great, a person or piece of hardware becomes overstressed and cannot recover. In such cases, the committee must

- Conduct an evaluation to determine if significant changes in the activity contributed to the cause of the incident;
- Identify the change(s) that overstressed the activity beyond the point of recovery;
- Determine why the change occurred.
- A useful change evaluation process developed by Kepner and Tregoe[4] consists of
    - — Descriptions of the incident and a comparable safe situation, including a comparison of these two situations outlining the differences that set them apart;
    - — Identification of any changes about each difference;
    - — Evaluation of the changes to determine if they may have caused the incident. Give careful attention to obscure and indirect relationships (e.g., a change in color or finish may change heat transfer parameters). In complex systems, pay particular attention to the compounding of changes.

### 5.8 Evaluation To Determine Root Cause

A root cause is the basic cause of an incident that, if corrected, would prevent a recurrence of a similar incident. A systemic root cause explains why an incident occurred by focusing primarily on deficiencies in the authorizing organization. The following are two acceptable methods for determining the systemic root cause:

#### 1. MORT: The Management Oversight and Risk Tree (MORT)[5]

This technique provides a thorough and detailed analysis of occupational accidents and other incidents. It uses a decision-tree diagram to arrange safety program elements logically and completely, and detects the errors and omissions of an activity in order. MORT consists of two main branches: "barriers" (specific control factors) and "management system factors," which are connected by an *And gate*. Thus, an incident is the result of both a barrier and management system factor that were less than adequate. The management system factor allowed the barrier to be less than adequate. A complete

MORT chart contains over 1000 basic elements and requires extensive training to use it effectively. This type of chart, however, can be helpful in evaluating complex incidents.

### 2. A Root-Cause MiniMORT Chart

This chart was developed for use at LLNL. It is simpler, easier to use, and provides direct information about the systemic root cause(s) of the incident under analysis. For instructions on using this chart, see Appendix E, "LLNL Root Cause MiniMORT."

In addition, root causes given in Document 4.3 are used for making occurrence reports to DOE.

# 6.0 Preparing the Incident Analysis Report

## 6.1 General

The incident analysis is a closed-loop iterative process that consists of gathering information, evaluating and organizing the information, and formulating various hypotheses to explain how the incident occurred. This process continues until the committee fully understands *how* and *why* the incident occurred and is satisfied that all significant discrepancies and inconsistencies are resolved. Once this process is completed, one or two members of the committee are assigned to draft the first three sections of the report for review. The remainder of the report is written after the committee approves the first three sections.

## 6.2 Report Format and Contents

For uniformity, the Incident Analysis Report shall be prepared on the form shown. If additional pages are required, use blank paper and include the incident analysis report number, report date, and page number on each page. The report shall consist of the sections below.

### 6.2.1 Summary

The information in each of the subsections that follows shall be entered at the beginning of every LLNL incident analysis report so that the incident can be easily recognized.

***Report date and serial number***—Use the date the committee approved the report. The report serial number is obtained from the ES&H Team and shall also be included in the *Incident Analysis Committee Appointment Memo*.

***Short Description***—Clearly and concisely state the basic nature of the incident.

***Type***—List the type of incident analysis committee (or investigating board) that conducted the analysis (see Section 1.4).

***Date***—Give the date of the incident in numeral form (e.g., 2/11/91).

***Time***—Give the time of the incident on the 24-hr clock (e.g., 1346 hr).

***Location***—Describe the location of the incident. Use the building number or some other frame of reference.

***Departments Involved***—List all of the departments that played a major role in the incident.

***Injury or Illness***—Describe the injury or illness. This description can be obtained from the Supervisor's Accident Analysis Report (SAAR) generated by the Hazard Control Department's Occupational Accident/Injury/Illness Analysis Support and Information System (OAASIS). Also include the serial number from the SAAR form. *Hazardous Materials*—Describe any hazardous material involved in the incident.

***Property Damage***—Estimate the dollar value for replacing or repairing any property damaged in this incident. Include the cost of decontamination, if any. Appendix F, "Criteria for Estimating Monetary Losses," gives the criteria for estimating costs.

### 6.2.2 Information

This section should contain a concise description of the events and personnel involved in the incident. It may be even further subdivided into subheadings such as "Incident Sequence," "Training," "Safety Procedures," "Laboratory Analysis," and "Management Responsibilities," as appropriate. Use the TOE chart as a guide (see Figure E-1). *The committee's activities should not be included here.*

Assumptions made in the report should be identified as such, and information that cannot be found should be so stated. One or two photographs, including other documents that may be essential in understanding the incident, may be attached to the report when necessary (see Section 6.3). Attachments should be identified appropriately (e.g., Attachment 1) wherever they appear in the report.

The objective of an incident analysis is to reduce risk, not to fix blame. Thus, descriptive job titles (e.g., technician "A," chemist "A," and group leader "B") should be used to represent the official names of those involved in the incident. On a separate sheet of paper, however, document the title assigned next to the employee's official name and employee number. Mark this sheet "In Strict Confidence" and forward it to the

appointing manager with the incident analysis report. *The committee shall not retain or distribute any other copies of this sheet.*

### 6.2.3 Committee Comments

The committee should comment on its activities in this section (e.g., how it felt about certain aspects of the incident, how or why it arrived at the conclusions it did). Laudatory comments about someone involved in the incident should also be documented here. *This section should not contain descriptive information about the incident.*

### 6.2.4 Conclusions

The conclusions drawn from the incident analysis shall be prepared only after the committee agrees with the draft of the first three sections. The committee should summarize in a step-by-step manner the key events involved in the incident, including those associated with the amelioration efforts. The conclusions should originate only from the data in Sections 6.2.1 and 6.2.2. They should support the facts and integrate all significant information so that readers can easily grasp the specifics of the incident.

### 6.2.5 Root Causes

State the systemic root cause as determined by either of the two methods described in Section 5.8.

### 6.2.6 Judgments-of-Need

Each judgment-of-need is a written statement of the recommended action management should take to correct a root cause. The committee reviews each root cause and either (1) formulates a judgment-of-need which, if implemented, will reduce the risk for recurrence of that root cause; or (2) recommends that the risk for the root cause should be recognized by management as an acceptable risk. Each judgment-of-need is numbered individually to simplify action assignment and completion control.

A judgment-of-need must address an organizational or systemic correction; it should not be a one-time fix. For example: An incident occurs in a plant when a leak develops in a piping system carrying a toxic substance. Upon completing an analysis, it was found that the gaskets (made of material "A") used in the piping system reacted with the toxic substance over a long period. The gradual breakdown of gasket "A" allowed the toxic material to leak. The following are two possible judgments-of-need for this condition:

1. Survey the plant and, where this condition is found, replace all gaskets "A" with gaskets "B" (made of material that will not react with the toxic substance).

2. Survey the plant and, where this condition is found, replace all gaskets "A" with gaskets "B" AND provide some organizational mechanism to prevent gaskets "A" from being used in the future.

The second judgment-of-need, although more difficult to implement, has a much greater chance of reducing the risk of a future incident because it provides a long-term correction.

### 6.3 Assembly, Review, and Approval of the Final Draft

The committee shall do the following:

- Assemble a final draft of the report and any attachments for review and comments. Attachments should include the TOE chart (if one was prepared) and photographs or maps if they will help the reader understand how the incident occurred. Each item attached to the report must be numbered, labeled, and mentioned in the report.
- When appropriate, permit others to review the draft before it is sent to the appointing manager.
- Provide the Office of the Laboratory Counsel and LLNL Risk Management with a copy of the draft for review.
- Incorporate appropriate changes before finalizing the draft. All recommendations for changes shall be given consideration.
- A majority of the committee must agree with the draft before it can be approved and signed. Once approved, no one (including the appointing manager) shall make changes to the report without the committee's consent.

### 6.4 Report Transmittal and Committee Closeout

The committee chairperson shall prepare and send the following to the appointing manager:

- *Transmittal Memo.*
- The *Incident Analysis Report*, including attachments and the sheet marked "In Strict Confidence."
- Any supplemental information the committee deems necessary to retain.

Materials that are not needed shall be returned to the original source or discarded by the committee and the appointing manager. *The committee is not authorized to provide copies of the final report or the sheet marked "In Strict Confidence" to anyone except the appointing manager.*

Unless additional action is required, the committee may be disbanded after the final report is submitted to the appointing manager.

# 7.0 Final Action by the Appointing Manager

## 7.1 Taking Action on the Judgments-of-Need

The appointing manager is responsible for the following:

- Initiating action for each judgment-of-need that seems reasonable and appropriate to correct the root cause and prevent recurrence of the incident. Managers must provide for long-term correction of the root cause, not a one-time fix (see Section 6.2.6).
- Preparing the Appointing Manager Memo, and distributing it with a copy of the incident analysis report to the following:
  - The Director's Office.
  - The assurance manager for the directorate that appointed the incident analysis committee.
  - The Incident Analysis Report Archive in the Hazards Control Department. A copy of the sheet marked "In Strict Confidence" should be attached.
  - Other managers (if any), including their directorate assurance managers, who will need to take some action on the judgments-of-need.
- Sending copies of the incident analysis report to other organizations within the Laboratory and DOE complex if the information in the report may help such organizations reduce a risk associated with their operations.
- Entering all *accepted* judgments-of-need (i.e., corrective actions) in the LLNL Deficiency Tracking System (DefTrack). If a judgment-of-need will be addressed by another Directorate, provide that Directorate with the information so it can be considered for entry into that Directorate's DefTrack system.

If a judgment-of-need cannot be implemented because of time constraints or costs, the manager may decide not to take action and accept a recurrence of the incident as an acceptable risk. This decision should not be made without careful consideration of the consequences.

### 7.2 Closing Out a Completed Incident Analysis

Upon reaching a decision for each judgment-of-need in an incident analysis report and taking all required corrective actions, the appointing manager shall close the incident analysis by sending a memo to the following:

- Director's Office.
- Assurance manager for the directorate that appointed the incident analysis committee.
- The Incident Analysis Report Archive in the Hazards Control Department.

The memo should describe the action taken on each judgment-of-need. If no action is required for a particular judgment-of-need, the memo should state so and give the reason for such decision. *Do not forward this memo until all corrective actions have been completed.*

Each appointing manager is the primary custodian of the incident analysis report and supplementary documents produced by the incident analysis committee. The Hazards Control Department is the secondary custodian and serves as the central archive for all LLNL incident analysis reports. These documents shall be retained for 75 years by both the primary and secondary custodians.

## 8.0 Work Standards

DOE O 231.1 Chg2, "Environment, Safety, and Health Reporting"

Document 4.3, "LLNL Implementing Procedures for DOE Order 232.1, Occurrence Reporting and Processing of Operations Information" in the *ES&H Manual*.

DOE O 225.1A, "Accident Investigations"

## 9.0 References

1. Buys, J. R. and Clark, J. L., *Events and Causal Factors Charting*, Rev. 1, DOE/SSDC 76-45/14, U.S. Department of Energy, Washington DC, 1978.
2. Benner, L., Jr., "Multilinear Events Sequencing Methods," *J. Safety Research*, 7:2, 1975.

3. Rigby, L. V., *Nature of Error*, Sandia National Laboratory, Albuquerque, New Mexico, 1970 (previously published by the *Amer. Soc. for Qual. Cont.*).
4. Kepner, C. H. and Tregoe, B. B., *The New Rational Manager*, McGraw-Hill, New York, 1981.
5. Johnson, W. G., *MORT: The Management Oversight and Risk Tree*, SAN 821-2, U.S. Department of Energy, Washington DC, 1973

# 10.0 Resources for More Information

## 10.1 ES&H Contact List

## 10.2 Other Sources

Ferry, T. S., Modern Accident Investigation and Analysis, An Executive Guide, John Wiley & Sons, New York, 1981.

Fillmore, D. L. and Cornelison, J. D., MiniMORT Presentation Guide, U.S. Department of Energy, Washington DC, 1986.

Hendrick, K. and Benner, L., Jr., Investigating Accidents with STEP, Marcel Dekker Inc., New York, 1987.

Johnson, R. D., "Simplifying MORT for Supervisors," National Safety News, Sept. 1984., p. 71-74.

Johnson, W. G., Accident/Incident Investigation Manual, 2nd ed., DOE/SSDC 76-45/27, U.S. Department of Energy, Washington DC, 1985.

Kuhlman, R., Accident Investigation, International Loss Control Inst., Georgia, 1977.

National Safety Council, Accident Investigation, A New Approach, NSC, Chicago, 1983.

# Appendix A

## Terms and Definitions

| | |
|---|---|
| Accident | An incident that results in injury, illness, property loss, or environmental damage. |
| Appointing manager | A member of management that appoints an incident analysis committee, receives its report, and determines which judgments-of-need in the report should be implemented. |
| Danger | A high-risk hazard. |
| Emergency | An incident that requires immediate control to prevent continuing loss. |
| Hazard | A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to a facility or to the environment (without regard for the likelihood or credibility of accident scenarios or consequence mitigation). |
| Incident | An incident is a sequence of events that could result in an accident, injury, illness, and/or reportable occurrence. The term "incident" is used to broadly encompass many types of events because numerous environment, safety, and health (ES&H) requirements for incident notification, analysis, and reporting do not allow for simple categorization or development of procedures for each type of incident. The Department of Energy (DOE) uses the word "occurrence" instead of "incident." |
| Incident analysis report | A written report prepared by an incident analysis committee that describes the cause(s) of an incident and identifies the judgments-of-need to avoid a recurrence. |
| Injury | Damage to the body such as a cut, laceration, fracture, sprain, amputation, or a single traumatic event associated with exposure to chemicals, toxic agents, or radiation. |

| | |
|---|---|
| Illness | An acute or chronic disease or disorder (other than that which may have come from an injury) caused by inhalation, absorption, ingestion, direct contact, or radiation. See the examples below.<br><br>*Skin diseases or disorders*—Dermatitis, eczema, or a rash caused by primary irritants, sensitizers, or poisonous plants; oil acne; chrome ulcers; and chemical inflammations.<br><br>*Dust diseases of the lungs (pneumoconiosis)*—Silicosis, asbestosis, black lung, and byssinosis.<br><br>*Respiratory conditions due to toxic agents*—Pneumonitis; pharyngitis; farmer's lung; rhinitis; or acute congestion due to chemicals, dusts, gases, or fumes.<br><br>*Poisoning effects of toxic materials*—Poisoning by lead, mercury, cadmium, arsenic, carbon monoxide, hydrogen sulfide, organic solvents, insecticides, plastics, and resins.<br><br>*Physical agent disorders*—Heatstroke, heat exhaustion, freezing, frostbite, caisson disease, and the effects of both ionizing and nonionizing radiations (prolonged or repeated exposure to welding flash, ultraviolet rays, microwaves, or sunburn).<br><br>*Repeated trauma disorders*—Noise-induced hearing loss; synovitis, tenosynovitis, and bursitis; Raynaud's phenomena; and other conditions due to repeated motion, vibration, or pressure. *All other illness*—Anthrax, brucellosis, infectious hepatitis, malignant and benign tumors, food poisoning, histoplasmosis, and coccidioidomycosis. |
| Oaasis | (Occupational Accident/Injury/Illness Analysis Support and Information System) is an Oracle database application that provides an electronic method for entering, maintaining, reporting and storing accident/injury illness cases experienced at Lawrence Livermore National Laboratory. |
| Occurrence report | A documented report to the DOE of an event or condition that meets DOE's specified reporting criteria. |

| | |
|---|---|
| Recordable injury/illness | An occupational injury or illness that must be formally recorded because it includes at least one of the consequences given below:<br>• Fatality<br>• Lost workday<br>• Diagnosed illness<br>• Loss of consciousness<br>• Medical restriction<br>• Transfer to another job<br>• Repetitive trauma<br>• Medical treatment beyond first aid |
| Risk | A quantitative or qualitative statement that describes the potential damage, injury, or loss as a result of a hazardous event or agent, taking into account both the severity of the consequences and the likelihood of occurrence. |
| Root cause | The most basic cause(s) that, if corrected, will prevent recurrence of an incident. |
| Safe | An operation or state where the risks are judged acceptable. |
| Saar | Supervisor's Accident Analysis Report. |
| Work supervisor | A member of management who has direct control and evaluates how others perform their work activities. |

# Appendix B

## Sample Memoranda and Forms

This appendix contains samples of the following:

- Incident Analysis Committee Appointment Memo.
- Incident Analysis Interview Record.
- Incident Analysis Report, which the committee should reproduce as needed.
- Transmittal Memo, which the incident analysis committee sends to the appointing manager with the incident analysis report.
- The Appointing Manager Memo, sent to other managers requesting action on specific judgments-of-need.

If necessary, the memoranda in this appendix may be modified so that they are more suitable for a particular incident. Editorial comments are shown in brackets.

[Date]

INCIDENT ANALYSIS COMMITTEE APPOINTMENT MEMO

TO: [Committee Chairperson]

FROM: Appointing Manager

SUBJECT: Incident Analysis Committee Appointment

You are hereby appointed as chairperson of a committee to analyze an incident that occurred in building _____ on _____. The incident involves

[Describe the incident in general terms]

The committee shall gather, evaluate, and organize relevant information about this incident and prepare an incident analysis report. The report should include the root cause(s) of the incident and the judgments-of-need that will prevent a recurrence of similar incidents.

The following persons are appointed as committee members to assist you with this assignment:

This incident analysis shall be conducted in accordance with Chapter 4 and Supplement 4.08 of the *Health & Safety Manual*. Serial number _____ has been assigned by the Hazard Control Department and shall be used on the final incident analysis report and supplementary documents. The report should be submitted to me by _____.

Use account number _____ to charge all committee work associated with this analysis and to obtain any supplies the committee needs.

[Appointing Manager]

cc:

[Each committee member]
[Each member's dept. head / div. ldr]
[Facility manager of the building]
[Program leader, if not the appointing manager]
[Assurance manager]
[Others as appropriate]
Incident Analysis Report Archive,
Hazards Control Department, L-383

# Incident Analysis Interview Record

Name _____ Date _____ Time _____ By _____

Job_____ Phone _____ Page _____ Of _____

Notes

| Follow-up questions | Observer's comments |
| --- | --- |
| | |

**INCIDENT ANALYSIS REPORT**

A. SUMMARY Report Date _____ Serial No._____

| | | | |
|---|---|---|---|
| 1. SHORT DESCRIPTION | | | |
| 2. TYPE | 3. DATE | 4. TIME | 5. LOCATION |
| 6. DEPARTMENTS INVOLVED | | 7. INJURY/ ILLNESS | CLASSIF. CODE _____ |
| 8. HAZARDOUS MATERIALS | | 9. PROPERTY DAMAGE | $_____ |

[Date]

TRANSMITTAL MEMO

TO: [Appointing Manager]

FROM: Incident Analysis Committee

SUBJECT: LLNL Incident Analysis Report, Serial No. _____
[Title of Report]

The incident analysis report prepared by this committee is attached for your review. It includes the root cause(s) of the incident and the judgments-of-need to help you develop a plan of action to prevent a similar recurrence.

A list of the names of individuals mentioned in the report (stamped "In Strict Confidence") is attached to this memo. This list should also be attached to the incident analysis report that is sent to the Incident Analysis Report Archive in the Hazards Control Department. It should not be distributed with the re-port. Other documents attached to this memo may be filed at your discretion.

You shall request an action plan from other managers if some judgments-of-need are not completely under your control. When all the action plans are implemented, the risk for a similar incident will be reduced. Guidelines for the actions required are given in Chapter 4 and Supplement 4.08 of the *Health & Safety Manual*.

We encourage you to disseminate this report to anyone who may benefit from it.

[Committee Chairperson]

Attachments
The complete incident analysis report with appendices (if any)
List of individuals involved (marked "In Strict Confidence")
[Additional information, e.g., extra photos, lab reports]

[Date]

APPOINTING MANAGER MEMO

TO: Distribution

FROM: Appointing Manager

SUBJECT: LLNL Incident Analysis Report, Serial No. _____
[Title of Incident Analysis Report]

The committee I appointed to analyze the incident described above has completed its report. A copy of that report is attached to this memo. After review-ing the root cause(s) and the judgments-of-need recommended in this report, I will take the action described below for each judgment-of-need listed:

> [List the judgments-of-need by the numbers assigned in the incident analysis report and describe the action you intend to implement. If you feel no action is justified for a particular judgment-of-need, give the reason for this decision.]

[Include the following paragraph only if additional action is required.] In addition, you should review the attached report and evaluate judgments-of-need Nos. _____ to determine the action you feel is appropriate since these judgments fall within your area of responsibility. Please advise me in writing within 30 days of your plan of action. Also, send
a copy of your response to the Director's Office (L-1), your Directorate's Assurance Office, and the Incident Analysis Report Archive in the Hazards Control Department (L-383).

[Appointing Manager]

Action Addressees:

> [If required]

Info. Copy [Copies must *always* be sent by the appointing manager to the following:]

> Director's Office, L-1
> Various Directorate's Assurance Office involved
> Incident Analysis Report Archive,
> Hazards Control Department, L-383

# Appendix C

# Guidelines for Conducting the Interview

## C.1 The Welcome

- Welcome the interviewee and introduce all parties at the interview.
- State the purpose of the interview (i.e., to obtain information about the incident).
- Emphasize that the role of the committee is to find ways to prevent a recurrence of the incident, not to find who is at fault. Every attempt will be made to keep the identities of the individuals involved confidential.
- Stress that the committee is neutral and unbiased in this matter.
- Explain that committee members will take notes during the interview to ensure accuracy of what was said.
- Ask the interviewee to state his/her name, work location, job classification, and involvement in the activity at the time of the incident.

## C.2 Obtaining Information about the Incident Sequence

- Ask the interviewee to tell what he/she knows about the incident. Use a broad question such as, "Would you tell us what you know about this incident"?
- Ask short, simple questions to clarify anything the interviewee said; begin with the chairperson and proceed from member to member. Committee members should be courteous. No member should interrupt or take the interview away from another.

## C.3 Obtaining Information about How the Activity Was Planned and Conducted

The following questions may be asked to gather information about how the activity involved in the incident was planned and conducted:

- Was an ES&H evaluation made while planning the activity? Were hazards identified and risks evaluated?
- Was the ES&H Team contacted for assistance? Was the team's response adequate?

- Was the hardware (facilities and equipment) adequately designed to provide a tolerance range wide enough for the man-hardware interface? Was the design reviewed?
- Was the equipment properly obtained and installed? Was it tested before use? Was there a functioning inspection and maintenance plan?
- Were pertinent codes and standards available, and were they incorporated into the control plan?
- Were personnel adequately selected and trained for this activity? Were provisions made for training and upgrading the skills of new personnel?
- Was the possibility of worker performance errors provided for when the activity was planned?
- If abnormal environmental factors (e.g., wind, rain, ice, snow, heat, humidity, noise, lighting, high altitude, and time) were of significance in this activity, were adequate countermeasures planned and taken?
- Was a reasonable combination of physical barriers and behavioral controls selected for this activity?
- Were any special emergency controls required for this activity, and were they working?
- If an ES&H procedure was required for this activity, was it available and functioning? Were job instructions prepared and followed?
- Was the MPR performed before starting the activity? Was the correct hardware available? Were controls and barriers in place and working? Did the supervisor know whether those involved with the activity were physically fit or capable of performing the work required?
- Did the supervisor observe the activity in progress, and was he/she satisfied with the conduct of operations? If the supervisor noticed any changes in work practices, did he/she reacted correctly?
- If drugs, alcohol, family problems, or emotional disturbances contributed to any performance error observed in this incident, were efforts made to solve those problems before the incident?
- If supervisors or fellow employees observed performance errors, were good-faith efforts made to correct these errors?
- If some action could have been taken at the onset of the incident to reduce its impact, was it taken? Did operating personnel and others in the vicinity respond to the incident properly? Was the organization's emergency plan followed?

- Did emergency response personnel respond, follow their plan, and perform effectively?
- If a similar incident occurred before, was adequate remedial action taken?
- Were management support services and upper management's vigor and example evident prior to this incident?
- Did management take reasonable measures to prevent this incident from occurring?
- Did you have any concerns prior to the incident, and did you discuss such concerns with your supervisor or the Hazards Control Department?

Ask the following if the answer to any of the above questions is "no." Answers to these questions usually will uncover the root cause(s) of an incident.

- Why was corrective action not taken before the incident?
- Why was the situation tolerated?
- Why did activity planning not anticipate and control the conditions that caused the incident?

### C.4 The Closing

Upon completing the interview, the chairperson should thank the interviewee and explain that another interview may be necessary if additional information is needed.

Encourage the interviewee to talk with the committee if he/she thinks of additional information that may be helpful to the incident analysis.

# Appendix D

# Time-Ordered Events Charting

## D.1 Preparation of a TOE Chart

Below are the rules for preparing single-line and multi-level TOE charts. The single-line TOE chart method is described in detail in the DOE booklet, *Events and Causal Factors Charting* (see reference in Section 8 of this supplement).

1. Construct the chart using a large sheet of paper, a chalkboard, or even the wall of a room.

2. Enter each event or condition on a 3- x 5-in. index card or pregummed sheet with the date and time the event occurred in a lower corner. Each card must clearly describe a discrete action of one operator using a noun and an active verb. A modifying phrase may also be added.

3. Enclose an event from validated information within a solid rectangle. Use a dashed rectangle if the event is only presumptive.

4. Start the chart with the card that describes the incident event, adding horizontally other cards that describe the events of the operator primarily associated with the incident. Cards should always be placed in time sequence, going from left to right. If each event in the sequence is not derived logically from the one preceding it, leave a space between the event for the missing information. For multi-level TOE charts, add the cards describing the events associated with other operators at different levels above or below the event sequence of the principal operator. Vertically align the event cards for different operators only if the events occurred at the same times. This way, time will run along the abscissa and different operators will run along the ordinate.

5. Add cards that describe any special conditions under which a particular event occurred above or below the event card to which they refer. Enclose validated conditions in solid ovals and presumptive conditions in dashed ovals.

6. Show interrelationship between events and conditions with lines or arrows.

7. Identify questions that still need to be answered using cards with distinctive colors. Place these cards in the appropriate location on the chart.

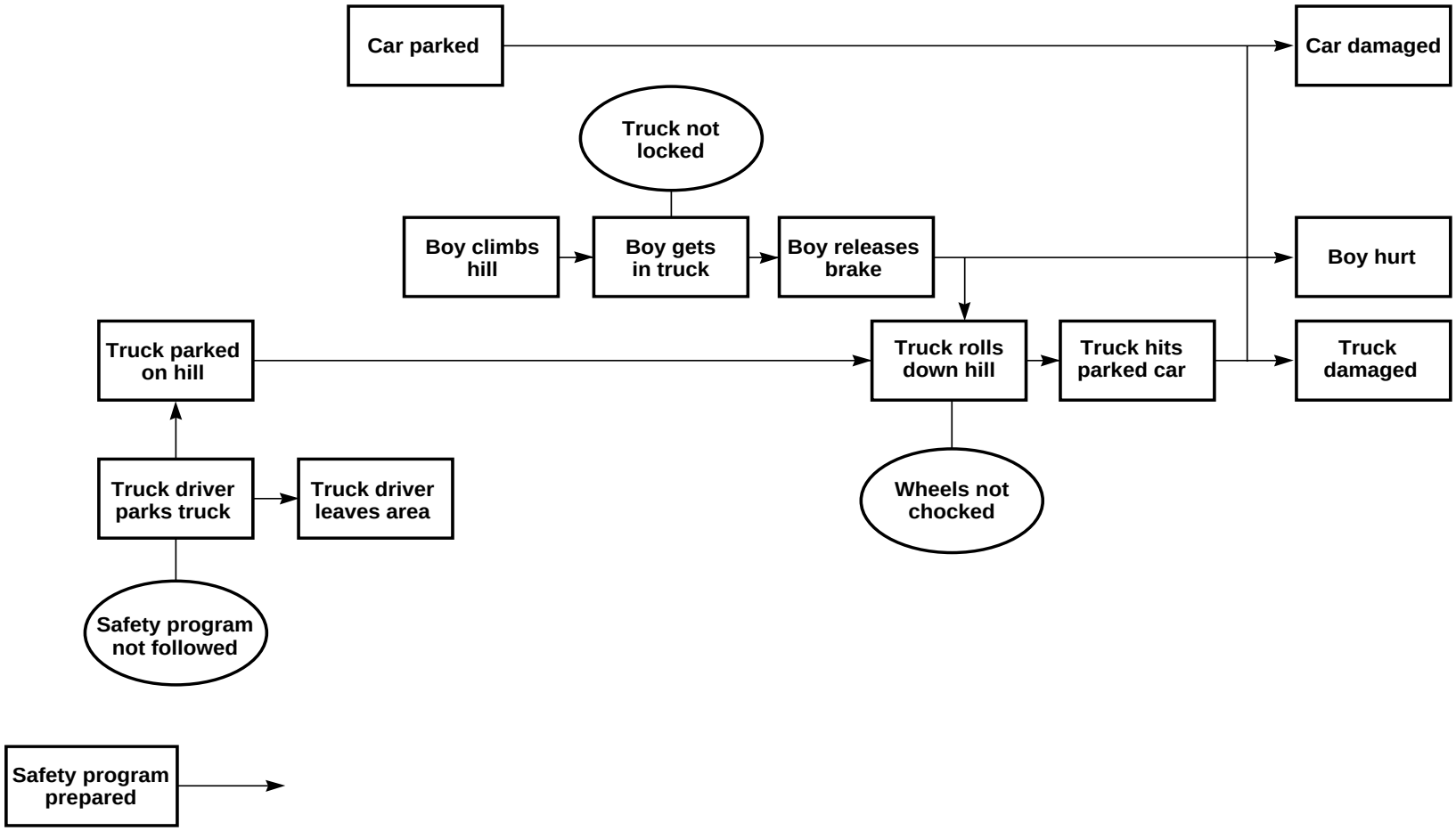
All significant information the committee collected will be in the TOE chart, which can be used to explain how and why the incident occurred. This chart will also be useful when the committee formulates its conclusions and judgments-of-need and prepares the incident analysis report.

## D.2 Example Using a Multi-Level TOE Chart

**Incident Analysis Information.** A construction company was awarded a contract to build a condominium on a hill overlooking the city. Before the project started, a comprehensive safety program was developed to cover all aspects of the project. Construction activities began on Monday, October 4, and proceeded without incident through Friday, October 8, at which time the project was shut down for the weekend. Drivers involved with this project left several company vehicles, including a 2-1/2-ton dump truck, at the construction site.

On Saturday, October 9, a nine-year-old boy who lives four blocks from the construction site climbed the hill and began exploring the project site. Upon finding the large dump truck unlocked, he climbed into the cab of the truck and released the emergency brake. The truck began to roll down the hill, rapidly picking up speed. The boy was afraid to jump out and did not know how to apply the brakes. The truck crashed into a parked car at the bottom of the hill but remained upright. The boy suffered serious cuts, lacerations, and a broken leg. Although the safety program specified that unattended vehicles should be locked and the wheels cocked, there was no verification that these rules had been communicated to the drivers.

**Discussion.** The facts in this scenario are shown in Fig. D-1. Notice that each operator is shown on a separate line and each event is placed in a time-ordered sequence. If known, the date and time of the event can be placed in one of the lower corners of the box, and the identity of the information source can be placed in the other. Presumptive events and conditions are indicated with dashed boxes. NOTE: The safety program line never intersects with the drivers' because no information was available to show that the drivers were informed of the rules for parking the truck.




TCF-001-U-32154-03

# Appendix E

# LLNL Root Cause MiniMORT Analysis

## E.1 Introduction

The Management Oversight and Risk Tree (MORT) developed by DOE was designed to evaluate the effectiveness of the operational system and safety program of an activity as they existed at the time of an incident. Use of this complete MORT requires an analyst to have extensive training in the techniques involved. The LLNL Root-Cause MiniMORT (RCMM) was designed for individuals who may not have had MORT training but still want the benefits of a MORT-style analysis. The RCMM and the MORT are forms of fault-tree analyses that use graphic symbols to illustrate the safety program elements that should be a part of every goal-oriented and high-performance management system.

The RCMM is used to determine the systemic root cause(s) of an incident. A systemic root cause of an incident is a less-than-adequate (LTA) management system element which, if corrected, would prevent a recurrence of a similar incident.

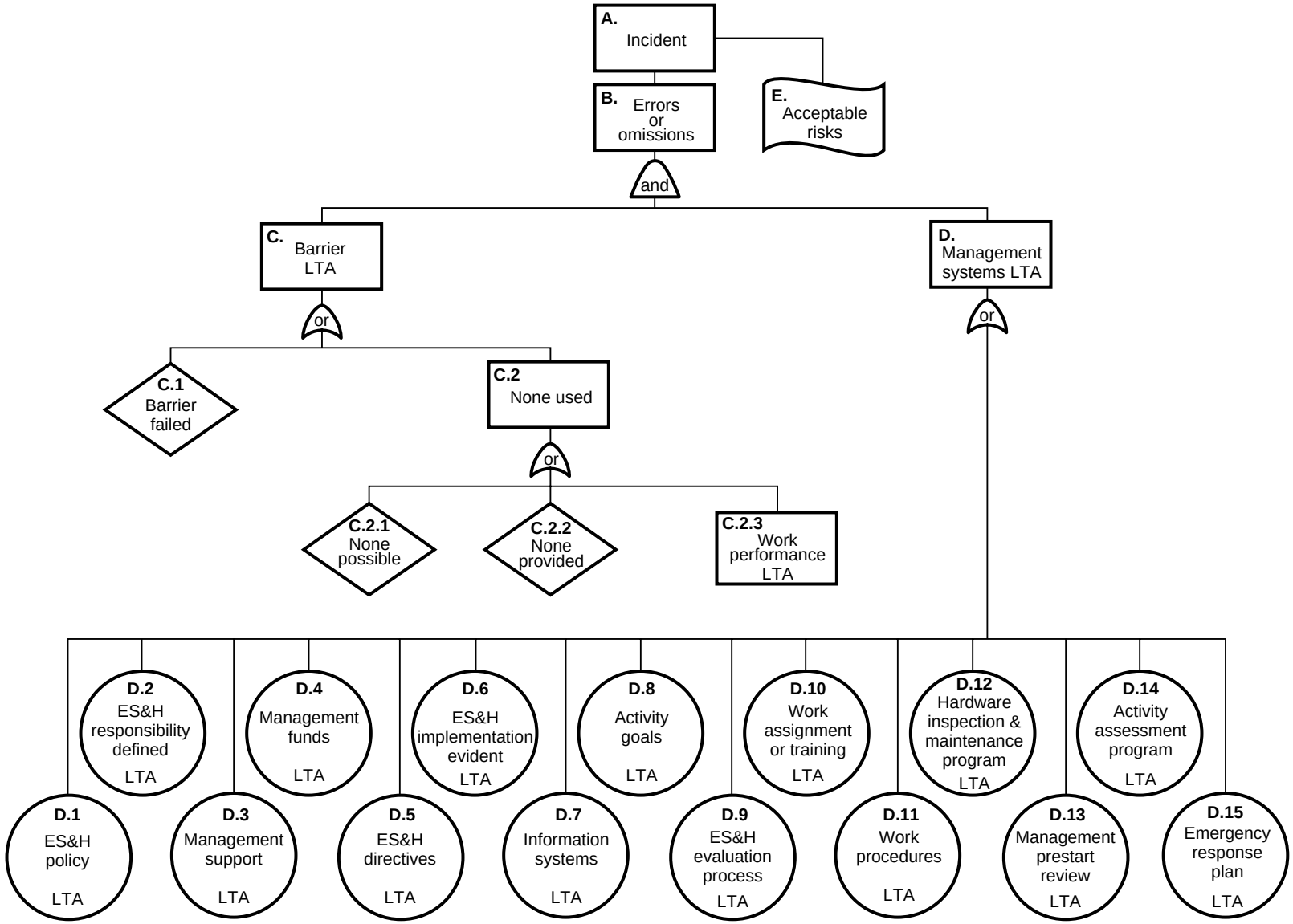
## E.2 RCMM Structure

The following are the definitions of the different graphic symbols used in Figure E-1:

- *Rectangle*—An element that has a more basic cause.
- *Circle*—A basic element (a systemic root cause) that is independent of other elements.
- *Diamond*—An element representing a risk found in an activity even though such risk was not formally accepted by management.
- *Scroll*—An element that should occur normally during an activity.
- *And Gate*—A logic gate that allows an output only when all input elements are present.
- *Or Gate*—A logic gate that allows an output when at least one input element is present.

## E.3 Determining Systemic Root Cause

Examine the elements in Fig. E-1 in alphabetical order to determine which elements were less than adequate based on the information gathered during the incident analysis.


A.
Incident
B.
Errors or omissions
E.
Acceptable risks
and
C.
Barrier LTA
D.
Management systems LTA
or
or
C.1
Barrier failed
C.2
None used
or
C.2.1
None possible
C.2.2
None provided
C.2.3
Work performance LTA
D.1
ES&H policy
LTA
D.2
ES&H responsibility defined
LTA
D.3
Management support
LTA
D.4
Management funds
LTA
D.5
ES&H directives
LTA
D.6
ES&H implementation evident
LTA
D.7
Information systems
LTA
D.8
Activity goals
LTA
D.9
ES&H evaluation process
LTA
D.10
Work assignment or training
LTA
D.11
Work procedures
LTA
D.12
Hardware inspection & maintenance program
LTA
D.13
Management prestart review
LTA
D.14
Activity assessment program
LTA
D.15
Emergency response plan
LTA

The systemic root cause(s) will be identified if you go through the chart completely. *The text that follows is labeled alphabetically to correspond with Fig. E-1*.

### A. Incident

This element represents the following information:

- What happened?
- What unwanted losses (or potential losses) were sustained (e.g., number of injuries, amount of property damage, work downtime, program impact, reduction in morale, negative publicity)?
- What transfer of energy or work environment produced these unwanted losses? This information is obtained by tracing all harmful energy flows back to their sources.

This incident occurred because of errors and omissions on the part of someone involved with the activity (element "B") or because of an acceptable risk (element "E").

### B. Errors and Omissions

If an incident was caused by an error or omission, then both a barrier *and* a management system element were less than adequate. The management system is responsible for providing all reasonable and adequate barriers required for a safe workplace. Figure E-1 illustrates these two mutually inclusive reasons for errors or omissions by using an *And Gate* to connect the two branches of element "B."

The responsibilities of managers in this regard are described in Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *ES&H Manual*. See Section 5.5 of this supplement for a discussion of the role that errors and omissions play in causing incidents.

### C. Barrier LTA

The term barrier, as used in the MORT system, means either a physical barrier or a behavioral control (e.g., procedure, sign, warning device, training, admonition, and accepted practice). A barrier is less than adequate if it did not keep a person or object from interacting with harmful energy or away from an adverse work environment. If any of the following elements was less than adequate, the barrier was also less than adequate.

**C.1 Barrier Failed.** A barrier was provided and used, but it did not function as intended. The risk associated with this event may be acceptable (element "E").

**C.2 None Used.** This branch attempts to answer why a barrier was not used.

**C.2.1 None Possible**. A risk generated by a design or an operation that does not include a barrier for the hazard because no reasonable barrier was possible. The risk associated with this condition may be acceptable (element "E").

**C.2.2 None Provided**. Management did not provide a barrier. The risk associated with this condition may be acceptable (element "E").

**C.2.3 Work Performance LTA**. Although an adequate barrier was provided, it was not used. This event occurs because of a discrepancy in a worker's performance. Determine why the barrier was not used; transfer this information to element "D."

## D. Management Systems LTA

If a barrier is less than adequate, at least one element in the management system branch is also less than adequate (unless the cause was an acceptable risk). The basic elements of the management system branch are all phrased in terms of root causes. To identify the root cause of an incident, the analyst must determine which basic element, if corrected, would prevent a recurrence of the incident.

**D.1 ES&H Policy LTA.** Was there a written, up-to-date ES&H policy with a broad enough scope that addressed major problems likely to be encountered? Was this policy sufficiently comprehensive to include the major motivations (e.g., humane, cost, efficiency, legal compliance)? Was the policy adequate for implementation, and did it address all parts of the activity? Document 2.1 and Document 2.2 contain LLNL's ES&H policy and other ES&H related policies.

**D.2 ES&H Responsibility Defined LTA.** Was there a clear, written statement of ES&H responsibility for the line organization, from the top individual through the first-line work supervisor to the individual employee? Was this statement distributed and understood throughout the organization? Were specific ES&H functions assigned to staff departments (e.g., safety, personnel and training, engineering, maintenance, purchasing, transportation)? Document 2.1 and Document 2.2 describe LLNL's ES&H roles, responsibilities and authorities.

**D.3 Management Support LTA.** Has management provided the necessary support and guidance to the lower levels of the organization? Is there a formal training program for all management personnel that addresses general aspects of management and supervision, specific technologies, human relation and communications, and safety? Was the ES&H program a planned and measured program with low-cost/high-volume services, professional growth, and modern ES&H methods? Was the program organized with necessary and adequate elements? Did top management demonstrate an

interest in lower-level program activities through personal involvement? Were management's concerns known, respected, and reflected at all management and employee levels?

**D.4 Management Funds LTA.** Is the budget adequate not only for ES&H organizations but also for related ES&H program aspects for which other organizations have responsibility?

**D.5 ES&H Directives LTA.** Were there directives that emphasized the methods and functioning of the ES&H evaluation, monitoring, and other safety techniques rather than just specific rules for each kind of hazard? Are the directives published in an understandable manner? These directives are found primarily in the *ES&H Manual.*

**D.6 ES&H Implementation Evident LTA.** Was line management held accountable for ES&H functions under its jurisdiction? Were there methods for measuring management's performance? Were ES&H program elements implemented in a timely manner? Were solutions to ES&H problems introduced early in the life-cycle phase of projects? Were commonly recognized good engineering practices, including safety, reliability, human factors, and quality assurance, incorporated into the general design process? Was there a method for bypassing the usual delays to get an immediate correction for an imminent hazard or a problem with significant consequences? Was an "ES&H culture" evident in program activities that reflected a long-term concern for error-free performance (e.g., facility "conduct of operations" activities)?

**D.7 Information Systems LTA.** Were the information systems adequate to support the needs of the ES&H evaluation process? This evaluation includes the information management needs to determine what risks to assume? Was management kept informed of delays during the implementation of controls and barriers? If these delays were acceptable to management, did management understand that they were assuming these risks? Were the information systems capable of providing management with adequate information relevant to the work activity, and were there adequate means for providing exchange of this information to all levels? Did the information systems provide a subsystem for adequate ES&H information collection and analysis (e.g., a priority problem list)? Were the information systems capable of detecting deviations, determining rates and trends, initiating corrections, and in general ensuring that goals were attained? Information systems should include individuals that obtain, handle, and provide information in a communications network.

**D.8 Activity Goals LTA.** Did management define risk assessment goals while planning the activity? Were these goals compatible with policy and activity goals? Did management keep in mind that people and the environment were more important than the activity?

**D.9 ES&H Evaluation Process LTA.** Was the ES&H evaluation process properly conceptualized, defined, and executed while planning the activity? Were goals and tolerable risks defined for both ES&H and performance, and were any conflicts between the two resolved? Were the risks assumed by management identified and quantified? Was there a process to evaluate the risk resulting from a significant change? Were all applicable and appropriate ES&H requirements and sources of information (both internal and external) specified and made available?

**D.10 Work Assignment or Training LTA.** Was the work properly assigned, and were the steps and objectives necessary to carry out the work clearly defined? Were safety-related job requirements adequately defined so that individuals with the desired characteristics can be selected? Was the individual trained for the work he/she performed? Were the criteria used to establish training adequate in scope, depth, and detail? Were the methods used to meet the training objectives adequate? Was the trainer qualified to provide the training necessary? Did the individual assigned to the job meet established standards?

**D.11 Work Procedures LTA.** Did existing work and safety procedures meet the needs of the work activity? Were there adequate procedures for maintenance, inspections, operational requirements, hazardous materials and energy limits, safe shutdowns and emergencies, disposal, configuration control, and documentation? Were these procedures properly written and easy to understand? When necessary, were the procedures available to the worker? Did guidelines or controls exist to inform engineers, designers and ES&H staff of their limitations when writing documentation for activity personnel?

**D.12 Hardware Inspection and Maintenance Program LTA.** Were the necessary inspection and maintenance programs given consideration during the planning phase and through the rest of the life cycle of the activity? Were adequate inspection and maintenance plans available?

**D.13 Management Pre-start Review LTA.** Was the facility and process operationally ready? Were the necessary supplementary operations ready? Was the physical arrangement or configuration of the activity identical to that required by the latest drawings, specifications, and procedures? Was the ES&H evaluation properly executed, and were the hazards of the activity properly recognized? Were the pertinent safety and environmental controls specified in the *ES&H Manual*? Were work and safety procedures implemented before starting the activity? Did activity personnel complete the training that would make them cognizant of the hazards involved?

**D.14 Activity Assessment Program LTA.** Did supervisors and ES&H personnel regularly observe the work activity? Was the assessment program adequate for management to determine the risk? Did risk assessment include reviews of relevant incident analyses, results of self-assessment studies and inspections, internal and

external audits, health monitoring of activity personnel, and other relevant monitoring methods? Did the activity self-assessment program fulfill the requirements described in Document 2.2?

**D.15 Emergency Response Plan LTA.** An emergency response plan that is less than adequate can contribute to the severity of the incident even though the plan did not initiate the incident. Was there an adequate emergency plan in place before the incident took place, and was the plan properly executed? Were adequate resources allocated to properly execute the emergency plan? Did the plan properly evaluate the type and magnitude of the incident? If the emergency response efforts for this incident caused an additional incident, conduct an analysis of this new incident.

## E. Acceptable Risks

Was the risk that caused this incident understood and accepted by management? Was it a risk that management was authorized to accept? If the answer to both questions is "Yes," an acceptable risk may be listed as the root cause of the incident. Management should then review the barrier system associated with the acceptable (assumed) risk and either reconfirm the continued use of the barrier system without change or implement improvements that will lower the risk. If the answer to either question is "No," the root cause is not an acceptable risk but an element listed in "D."

# Appendix F

## Criteria for Estimating Monetary Losses

The following shall be included when estimating monetary losses:

- All estimated or actual costs to restore the Laboratory property to pre-accident conditions (without improvement), regardless of whether this is done or not. Where the accident involves property that has been lost, destroyed, or contaminated to a degree precluding economically justifiable recovery, estimates should be based on the cost of the actual re-placement and installation of identical buildings, equipment, or materials. For unused, obsolete, or excess buildings, equipment, or materials, use the estimated market value at the time of the accident. Credit should be allowed for the estimated salvaged value of items recovered.
- All estimated or actual costs from damage caused by the emergency response efforts.
- Post-accident cleanup expenses.

Do not include the following:

- Expenses resulting from the loss of the use of buildings, equipment, or materials affected by the accident.
- Post-accident expenses paid for by non-Laboratory sources (e.g., private insurance).
- Expenses resulting from the damage or loss of privately owned property, except to the extent that the Laboratory is liable for damage or loss consequences resulting from the accident.
- Expenses due to normal wear, provided that all of the loss is reasonably foreseeable and preaccepted. Unanticipated loss should be included (e.g., the cost for recovering or replacing released material and cleanup).